NROSCI 1046: Introduction to Computational Neuroscience

Class Meeting Location and Times: TuTh, 1:15-2:30pm, 120 Lawrence Hall.

Instructor: Dr. Chengcheng Huang

Office: Langley Hall A407; E-mail: huangc@pitt.edu

Office hours: Thursdays 4-5 pm. All office hours will be held on Zoom. The Zoom link will be added on Canvas.

Teaching assistant: Timothy Nolan, tnolan@andrew.cmu.edu. Tim will assist students with homework assignments and the final presentation, grade homework assignments and deliver recitations. Students can email Tim to ask questions or set up Zoom meetings for office hours. Students can also ask questions in the Discussion board on Canvas.

Lecture: All lectures will be recorded and live-streamed on Zoom. Lectures will be delivered synchronously at the assigned class time. The Zoom link for each lecture will be added on Canvas. I will mainly use slides for lecture presentation and sometimes share iPad screen for handwritten notes. After each lecture, the recording and slides will be posted on Canvas. All course material and notifications will be posted on Canvas. Depending on the operational posture of the university, I will deliver lectures either in classroom or remotely.

- Guarded Risk: I will give lectures in classroom, and lectures will be recorded and live-streamed on Zoom. Students can choose to come to the classroom or join the lectures on Zoom.
- Elevated Risk: All class activities will be remote. I will give lectures on Zoom.
- High Risk: All class activities will be remote. I will give lectures on Zoom.

Recitation: Tim will deliver recitations once a week, which will cover programming skills that are relevant for homework assignments and lectures, as well as supplementary mathematics and clarifications for the lectures. All recitations will be delivered synchronously on Zoom, and will be recorded and posted on Canvas afterwards.

Course description:
Computational neuroscience applies theoretical and numerical techniques to understand brain functions and neural coding. The first part of the course covers methods for analyzing
neural data, such as spike-triggered average, principal component analysis and population decoders. The second part gives a general introduction to several mathematical models of neurons and networks of neurons, and learning mechanisms for neural networks to perform computation. Students will learn how to use mathematics to study neural coding and network dynamics, and acquire programming skills in MATLAB. Knowledge of linear algebra, probability and differential equations is recommended, but not required.

Tentative course outline:

1. **Neural encoding**
   - Spike-triggered average, receptive field
   - Spike train statistics, Poisson process
   - Frequency analysis, autocorrelation, power spectrum
   - Dimensionality reduction, principal components analysis

2. **Neural decoding**
   - Single neuron decoding, signal detection theory
   - Population vector
   - Maximum likelihood estimate
   - Fisher information

3. **Single neuron models**
   - Integrate-and-fire neuron models
   - Noise-driven spiking
   - Short-term plasticity

4. **Population models**
   - Firing rate models
   - Competition models, attractor networks
   - Working memory and decision-making models
   - Phase plane analysis

5. **Learning**
   - Hebbian learning
   - Supervised learning
   - Reinforcement learning

**Prerequisites**: Intro to Neuroscience (NROSCI 1000, 1003) with a minimum grade of B-.
Calculus I (MATH 0220 or equivalent) with a minimum grade of C.

Additional Recommended Texts:


Grading: Six assignments (60%), final presentation (30%), comments and questions for other students’ presentations (10%). There is no final exam during the finals week. Grading scale: A/A±: 90-100%, B/B±: 80-89%, C/C±: 70-79%, D/D±: 60-69%, F: <60%. The grading policy does not depend on the risk posture of the university.

Assignments: The course will have 6 assignments. Each assignment will involve a significant MATLAB component and further analysis to be done by the student. For each assignment, students need to submit a write-up to describe the results, and the associated MATLAB code that can be run successfully and generates relevant figures. Students are welcome to work together on homework. However, each student must turn in his or her own assignments, and no copying from another student’s work is permitted. Each assignment needs to be submitted on Canvas before the due dates. Late homework will not be accepted.

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Assigned Date</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aug 24</td>
<td>Sep 4</td>
</tr>
<tr>
<td>2</td>
<td>Sep 8</td>
<td>Sep 18</td>
</tr>
<tr>
<td>3</td>
<td>Sep 22</td>
<td>Oct 2</td>
</tr>
<tr>
<td>4</td>
<td>Oct 6</td>
<td>Oct 16</td>
</tr>
<tr>
<td>5</td>
<td>Oct 20</td>
<td>Oct 30</td>
</tr>
<tr>
<td>6</td>
<td>Nov 3</td>
<td>Nov 13</td>
</tr>
</tbody>
</table>

Final presentation: The subject of the project should be a summary of one or more papers. Students will work in groups of two or three. I will post a list of papers on Canvas, from which students can choose to present. Students can also choose other papers outside the list. Each presentation should be about 10 minutes, and all group members take turns to present. All students must attend the presentation sessions, which will be on Nov 17 & 19 during the lecture time. Under the Guarded Risk posture, we will have presentations in
classroom, and presentations will be live-streamed on Zoom. Students can choose to come to the classroom or join on Zoom. Under the Elevated Risk or High Risk posture, we will have presentations on Zoom only. Students also need to comment on other groups’ presentations and ask questions, which will account for 10% of the final grade. Students need to email me the paper chosen to present and the names of other group members no later than Oct 20 (all group members must submit their own email).

Disability concerns: If you have a disability for which you are or may be requesting accommodation, you are encouraged to contact both me and Disability Resources and Services (DRS), 216 William Pitt Union, (412) 648-7890, drsrecep@pitt.edu, (412) 228-5347 for P3 ASL users, as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course.

Academic integrity: Students in this course will be expected to comply with the University of Pittsburgh’s Policy on Academic Integrity. Any student suspected of violating this obligation for any reason during the semester will be required to participate in the procedural process, initiated at the instructor level, as outlined in the University Guidelines on Academic Integrity. This may include, but is not limited to, the confiscation of the examination of any individual suspected of violating University Policy. Furthermore, no student may bring any unauthorized materials to an exam, including dictionaries and programmable calculators. To learn more about Academic Integrity, visit the Academic Integrity Guide for an overview of the topic. For hands-on practice, complete the Understanding and Avoiding Plagiarism tutorial.

Health and Safety: In the midst of this pandemic, it is extremely important that you abide by public health regulations and University of Pittsburgh health standards and guidelines. While in class, at a minimum this means that you must wear a face covering and comply with physical distancing requirements; other requirements may be added by the University during the semester. These rules have been developed to protect the health and safety of all community members. Failure to comply with these requirements will result in you not being permitted to attend class in person and could result in a Student Conduct violation. For the most up-to-date information and guidance, please visit coronavirus.pitt.edu and check your Pitt email for updates before each class.